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Case Report
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Cold Ceramic as a Root Canal Filling Material: A Case Series

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Abstract

Objectives: Recently, Cold Ceramic (CC), which is a mineral trioxide aggregate-like bio-ceramic and an essential component of calcium hydroxide, has been introduced as a potential root-end filling material. The purpose of this case series was to investigate the reliability and potential periapical healing effects of CC as a root canal-filling material.
Cases: In this study, six cases were described with complaints of pain and acute periapical abscess, who were managed in one visit using CC as a root canal filling material. After two weeks of follow up, they were clinically examined, which revealed no signs and symptoms in 12.33 months on average with a mean Periapical Index score of 1.33 (compared to initial mean score of 3).
Conclusion: Root canal filling with cold ceramic introduces clinicians to an alternative treatment strategy that might improve the healing outcomes for patients presenting with complex and challenging endodontic conditions.
Keywords: Root canal filling material; Case report; Mineral trioxide aggregate

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Introduction

The purpose of root canal treatment (RCT) is to reduce the burden of microorganisms inside the root canal and to treat periapical diseases. To accomplish this goal, mechanical and chemical cleaning along with an appropriate seal of the root canal space are required.[1] Complete removal of all microorganisms is not possible due to the complex anatomy of the root canal. Even with the most advanced cleaning tools and techniques, some microorganisms survive and continue to grow inside the root canal, leading to the failure of root canal treatment.[2] Filling the root canal with an appropriate root canal sealer can restrain the microorganisms from biofilm formation. Therefore, the ultimate goal of root canal treatment is to create a complete seal along the root canal from the canal entrance to the apical end of the root.[3] Filling materials' adaption to the canal wall prevents re-infection of the root canal.

The substances used for root canal obturation are critical determinants of the success or failure of endodontic treatment.[4] An ideal root-filling material should seal all pathways of communication between the root canal and periapical tissues, be nontoxic, noncarcinogenic, biocompatible, insoluble in tissue fluid, and dimensionally stable. Moreover, the presence of moisture should not affect its sealing ability; it should be easy to handle and show radiopaque features to be detectable on radiographs.[5] Several materials have historically been used for orthograde and retrograde filling of the root canal, including gutta-percha, calcium hydroxide, CEM cement, and bio-ceramics.

Gutta-percha, which is now the most commonly used material for root canal filling, has drawbacks such as cooling contraction and lack of adhesion to the dentinal wall. Even though Gutta-percha is the most popular filling material, it is sensitive to the entry of bacteria following direct or indirect contact with oral fluids.[6] Other filling materials such as ZEO-based, resin-based, and calcium-based sealers used for root canal treatment, despite the fact that they are applicable for different therapeutic purposes, act like a blood-contaminated environment and form large preapical lesions in some circumstances, which is far from expectations of optimal filling materials.[7] Recently, bio-ceramics have been shown to bypass the limitations of traditional filling materials.[8,9]

In the 21st century, a calcium hydroxide-based material known as cold ceramic (CC) was first introduced. The major structural components of CC are calcium oxide, silicon oxide, barium oxide, and sulfur trioxide, constituting 93% of its composition. Other components of CC include MgO, MnO, Fe_2O_3, Na_2O, K_2O, and TiO_2. Cold ceramic is a mineral trioxide aggregate (MTA)-like compound and can be used as a root-end filling material, an apical barrier in teeth with open apices, as well as for root perforation repair, pulp capping, and pulpotomy.[10] The purpose of this study was to evaluate the outcomes of treating obturated teeth with CC.

Case

The present case series study was approved by the Research Ethics Committee at Shahid Sadoughi University of Medical Sciences, Yazd, Iran under the code IR.SSU.DENTISTRY.REC.1401.012. Informed consent was taken from patients. Six patients with chief complaints of pain and occasional swelling were referred to Dr. Modaresi's private office (Yazd, Iran), and were managed by nonsurgical endodontic treatment using CC. The thorough procedure conducted for all six patients is

described below, providing pre/post-treatment preapical radiographs and the results of intra/extra oral examinations.

Several methods have been proposed for the use of bio-ceramics so far, summarized by Bogen et al. as the standard techniques of MTA compaction. The method used here was according to the lawaty technique, which can be used for a variety of bioceramic materials.[11]

In lawaty technique, following the cleaning and shaping of the canal system by the step-back or crown-down technique using a combination of 6% NaOCl (as the main rinsing agent) and normal saline (for final irrigation), MTA is mixed and transferred on the pulpal floor using a Glick instrument (an MTA container), until the access cavity is half filled. Initially, an apical plug measuring 4-5-mm is formed by circumferentially moving the K-file one size smaller than the MAF with an apical pumping motion, pushing the MTA from the access cavity container to the canal terminus. The authors also suggest using No. 20 NiTi pluggers or NiTi spreaders with the tip cut-off. Thereafter, the MTA can be pumped more aggressively without the risk of extrusion. It is recommended to take periapical radiographs during the procedure to ensure a dense MTA compaction. This method is suitable for canals with instrumentation to less than 50. For wider canals, a larger plugger may be needed.

The progression of K-files is then used to pump circumferentially after the formation of the apical MTA plug, sizing upward incrementally to 60 K-file to prevent possible void formation. After the application of the last file, the canal is half to two-thirds packed with either MTA or warm gutta-percha and sealer to facilitate future access for restorative purposes. In this method, normal saline is used for final irrigation without any interference with the setting of the material, obviating the need for the complete drying of the root canal.[9,11]

According to Strindberg's criteria, RCT is considered successful when a uniform lamina dura, a normal PDL contour, and soothing of the periapical radiolucent defect are all identifiable on radiographs. Clinically, there should be no pain or swelling.[12]

In the present study, after a two-week interval, all patients were assessed, and none of them showed any pain or swelling. Radiographic examination after an average of 12.33 months following the procedure revealed a mean Periapical Index (PAI) score of 1.33 (Table 1).

Table 1: Description of periapical index scores (adapted from Orstavik et al.[13] and Penesis et al.[14])

PAI* score	Description of Radiographic findings
1	Normal Periapical Structures
2	Small changes in Bone Structures
3	Change in Bone Structure with Mineral Loss
4	Periodontitis with well-defined radiolucent area
5	Severe periodontitis with exacerbating features

*PAI: Periapical index

Clinical Cases

Case 1: A 50-year-old female presented with pain originating from the maxillary left lateral tooth. The patient was in good health without apparent systemic disorders, and dental clinical examination revealed no evidence of mobility, probing defect, or apparent pathosis. Radiographic examination disclosed a previous root canal filling with a relatively extensive periapical lesion around the maxillary left lateral apex, measured approximately 5 * 5 mm (Figure 1a). Due to the lack of apical stop resulting from the previous treatment and apical enlargement, the decision was made to retreat the tooth with cold ceramic (SJM, Iran). The clinical diagnosis was acute periapical periodontitis. Following the administration of local anesthetics and rubber dam isolation, the access was prepared by applying an operating microscope (Zeiss Axiolab 5). The canal was obturated after chemo-mechanical debridement, cleaning, and shaping. Canal preparation was up to the #45 file following the step-back sequence. Irrigation was performed with NAOCL, and normal saline was used for final irrigation. The canal was sealed and obturated with CC following the manufacturer's instructions using an MTA carrier for carrying it to the canal space. Condensation was carried out by a number 20 plugger (Dentsply, Maillefer, Switzerland). The patient revisited two weeks later, complaining of no pain. Clinical examination showed the incisor to be functional and firm according to Strindberg criteria. The access cavity was filled with composite resin by a general dentist. Twelve months later, radiographic recall unveiled lesion healing and a uniform lamina dura and PDL, reflecting sufficient apical seal (Figure 1b). These observations substantiated the ability of CC to seal the defects between the canal and periodontium, evidenced by impressive healing features.

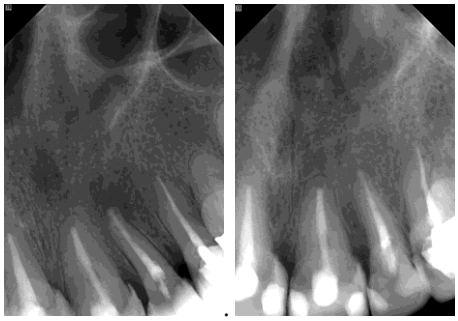

Figure 1: a) Maxillary left lateral tooth with previous RCT and remaining periapical lesion, b)12-month radiographic recall showing healing of the lesion.

Case 2: A 24-year-old man presented for a symptomatic left mandibular first molar. The patient was in good health, and a review of his medical history revealed no contraindications for endodontic treatment. The tooth had received nonsurgical endodontic treatment, which led to failure. A general dentist diagnosed the tooth prognosis as hopeless, as extensive furcation bone loss could be seen in radiographs following unsuccessful previous treatments; however, the patient insisted on preserving the tooth. Clinical examination showed no probing defects or periodontal disorders. The tooth was sensitive to percussion and had extensive furcation bone loss. A lesion was remarkable around the mesial apex. After clinical and radiographic examinations, the diagnosis was chronic apical periodontitis (Figure 2a). After explaining the therapeutic choices for the patient, retreatment with CC (SJM, Iran) was elected. After inducing anesthesia and rubber dam isolation, the access cavity was prepared. The previous obturation material was removed with gates glidden (size 1) (Denstply, USA). Due to previous over-instrumentation, apical constriction was destroyed, and gutta-percha sealing was inapplicable because the mesial canal was wide up to the size of 40 k-file (MANI K-files, MANI, Japan) and the distal canal up to the size of 80 k-file (MANI K-files, MANI, Japan). The decision was to fill both distal and mesial canals with CC. After chemo-mechanical debridement of the tooth with the step-back motion (irrigation with NaOCl and normal saline), the canals were sealed and obturated with CC following the manufacturer's instructions, using an MTA carrier for carrying CC to the canal space and pluggers No. 20 (the mesial canal) and No. 60 (the distal canal) for condensation (Dentsply, Maillefer, Switzerland). The canals were filled over the post-space because some small side canals needed to be sealed by CC. Cold ceramics entered the furcation from the accessory canals. Two weeks later, the patient was questioned whether the pain still existed. As the tooth was uneventful, the patient was referred to a general dentist to restore it with amalgam build-up. The patient came for follow-up five years later. Clinical symptoms were unremarkable and radiographic findings revealed clear healing of the lesion and the furcation bone loss (Figure 2b). Meanwhile, in five years, the second molar became cavitated, and another appointment was set to treat it.

Figure 2: a) Left mandibular first molar preoperatively: radiograph revealing extensive furcation bone loss and remarkable radiolucency around the mesial apex., b) 5-year radiographic recall showing healing of the furcation bone loss in which the mesial and distal canal was obturated with cold ceramic.

Case 3: A 16-year-old woman was referred for evaluation of the right mandibular first molar. The medical history of the patient showed no systemic disorders and contraindications of endodontic treatment. Clinical examination showed normal probing and no soft tissue problems. The tooth did not respond to vitality tests, indicating that it was necrotic. The tooth was also sensitive to percussion, and the patient stated that the tooth had spontaneous pain. Radiographic examination revealed PDL widening and periapical pathosis (Figure 3a). The case was diagnosed as chronic apical periodontitis. The patient had received various treatments for the tooth, and the final decision was retreatment of the molar with CC (SJM, Iran). Local anesthesia and rubber dam isolation were applied, and the access cavity was prepared under an operating microscope. Following chemo-mechanical cleaning and shaping using the step-back motion with hand files up to K-file #35 (Mani, Tochigi, Japan), irrigation was performed with NAOCL 6% and finally with normal saline. The canal was further obturated with CC following the manufacturer's instruction. For condensing CC, a number 20 plugger (Dentsply, Maillefer, Switzerland) was used. Furthermore, the pulp chamber was restored by Cavit dressing material, and the patient was referred to a prosthodontist for final restoration two weeks later and the pain was resolved. The patient returned for a recall 21 months later. A clinical examination revealed no discomfort or symptoms. A radiograph was taken from the first molar tooth, displaying a relative healing of the periapical lesion. Although some of the CC extruded from the root end, it did not interfere with bone healing, and the healing of the bone was remarkable (Figure 3b).

Figure 3: a) Right mandibular first molar's radiograph of the previous RCT showing PDL widening and periapical pathosis., b) 21-month recall displaying healing of the periapical lesion.

Case 4: A 24-year-old woman was referred with a problematic left maxillary second premolar tooth. The medical history of the patient displayed no specific disorders. The tooth had previous extensive 3-surface amalgam restoration and was sensitive to percussion. Pulp vitality tests were negative, and the tooth was necrotic but with no probing defects or periodontal problems. A radiographic examination disclosed a remarkable endodontic-related lesion at the tooth apex (Figure 4a). Local anesthesia and rubber dam isolation were applied; the previous restoration was removed, and root access was accomplished under an operating microscope. During cleaning and shaping, due to the widening of the canal, it was prepared to the size of 50 k-files (MANI K-files, MANI, Japan). Since gutta-percha could not provide enough apical seal, the decision was to obturate the canal with CC (SJM, Iran). The canal was filled with CC following the manufacturer's instructions (Figure 4b). Cold ceramic was carried to the canal using an MTA carrier. A number 20 plugger (Dentsply, Maillefer, Switzerland) was used for condensing CC; Cavit dressing was applied to temporarily restore the tooth, and the patient was referred for a permanent PFM crown. The patient returned after a follow-up period of two years with no pain or discomfort. A radiograph was taken for control, which displayed nearly complete healing of the periapical lesion and marked remineralization. The periodontal ligament also appeared clear and healthy (Figure 4c).

Figure 4: a) Left maxillary second premolar with previous extensive amalgam restoration and periapical lesion, b) RCT and obturation with cold ceramic, c)2-year recall radiograph revealing approximate healing of the bone and normal PDL.

Case 5: A 53-year-old woman visited to be evaluated for a symptomatic maxillary left second premolar. The patient had no systemic disorder, and a review of her medical history displayed a good health condition. The tooth had received root canal therapy to no avail. The patient had spontaneous pain and swelling, and the tooth was sensitive to percussion. The clinical diagnosis was necrotic pulp with acute periapical abscess. Radiographic examination revealed previous root canal therapy with gutta-percha, and the presence of a periapical lesion (Figure 5a), indicating treatment failure. After anesthesia and rubber dam isolation, the tooth was accessed to remove previous obturating materials using size 1 gates glidden, chloroform, and H-files (MANI K-files, MANI, Japan). After chemo-mechanical debridement of the tooth, the canal was obturated with gutta-percha (Figure 5b). Final radiograph revealed that treatment with gutta-percha was not successful because of penetration into the periapical tissue, resulting in its removal from the canal at the same appointment. Because of previous over-instrumentation and the inapplicability of insufficient gutta-percha sealing, it was decided to fill the canal with CC (SJM, Iran). The canal was obturated with CC following the manufacturer 's instructions using an MTA carrier and condensed by a spreader number 20 with the tip cut-off. The patient returned for follow-up four years later and did not complain of any symptoms. Control radiograph displayed the healing of the periapical lesion, and although some of the CC extruded from the root end, it had no interference with the healing process. Also, the resorption of CC was evident, and bone healing was favorable (Figure 5c).

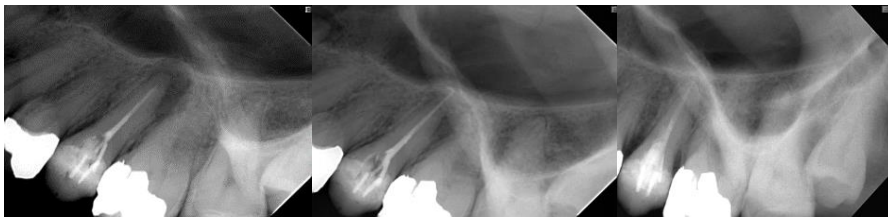

Figure 5: a) Maxillary left second premolar radiograph showing the previous RCT with gutta-percha, b) retreatment of the canal with CC, c) 4-year recall radiograph.

Case 6: The patient was a 40-year-old female who presented for an assessment of the right mandibular first molar. The medical history was non-significant, and the clinical examination showed no mobility or probing defects. An extraoral evaluation revealed normal soft tissue structure with no apparent pathosis. The tooth was sensitive to percussion, and vitality tests were negative. The tooth was necrotic with an acute periapical abscess, and due to severe decay, root canal therapy was necessary. Directly after anesthesia and rubber dam isolation, the tooth was accessed. After chemo-mechanical debridement and irrigation with normal saline, the decision was to obturate the canals with CC (SJM, Iran) using an MTA carrier following the manufacturer's instructions (Figure 6). A spreader with its tip cut off was used to condense CC in canals, and the Cavit was used for the temporary restoration of the pulp chamber. The patient was referred to a dentist for final amalgam build-up. After 30 months, the patient revisited with a normally functioning tooth with no symptoms. Consistently, a radiographic examination confirmed appropriate healing, a favorable apical seal, and a normal periodontal ligament (Figure 6b).

Radiographic assessment

The periapical status of the endodontic treatment was evaluated by the periapical index (PAI) scoring system given by Orstavik. [13] Table 2 represents the before-after PAI scores of all cases.

Figure 6: a) Right mandibular first molar's obturation with cold ceramic, b) 30-month recall radiograph confirming the healing of bone.

Table 2- Demographic information, tooth number (universal), follow-up and PA index before and after treatment

	Gender	Age	Tooth number	PA* Index before	PA index after	Duration of follow up
Case 1	Female	50	10	3	2	12 months
Case 2	Male	24	30	3	1	5 years
Case3	Female	16	30	3	2	21 months
Case 4	Female	24	13	2	1	2 years
Case 5	Female	53	13	4	1	4 years
Case 6	Female	40	19	3	1	30 months
Average				3	1.33	12.33 months

PA* Index: Periapical index

Discussion

The main goal of root canal obturation is to create a proper seal and prevent the penetration of micro-organisms into the root canal system. The stage of canal obturation can be a critical factor for the success of endodontic treatment. The ideal filling material must prevent re-infection of the root canal system, have satisfactory biocompatibility, and be bacteriostatic, radiopaque, sterile, insoluble, and user-friendly. The material must not be affected by tissue fluids and cause tooth discoloration.[15] Also, a proper filling material should deliver a good apical and lateral seal.[16]

In the last century, gutta-percha has been used along with sealers as the primary root canal filler. Dye penetration, fluid filtration, and bacterial leakage studies in vitro have shown vulnerability, especially with regard to coronal microleakage.[17] Various conditions may lead to recontamination of the root canal, including delayed coronal seal, poor quality of crown filling, and any crown fractures and caries.[18]

Torabinejad et al. tested coronal microleakage in teeth with root canal filling and noted that 50% of the extracted teeth were re-infected by bacteria after 19 to 42 days, depending on the type of the microorganism used.[19] Moazami et al.

showed that teeth with insufficient coronal seal had significantly higher rates of inflammation compared to other groups, and the group with inadequate seal had the highest periodontal ligament thickness. Also, the highest prevalence of dentin and cement dysfunction was observed in cases with inadequate seals. Also, bone analysis revealed intact tissue in only small areas in cases with inadequate seal.[20]

In the 21st century, a mineral trioxide aggregate (MTA)-like material named cold ceramic (CC) was first introduced. This material has been used as a root-end filler or an apical barrier in teeth with open apices, as well as for root perforation repair and pulp capping and pulpotomy. [21] Cold ceramic is a calcium hydroxide-based material that releases fine hydrophilic particles in the presence of moisture [22] The sealing ability and marginal adaptation of CC have been evaluated by various methods, such as electrochemical methods, dye penetration, and scanning electron microscopy.[22-24] The investigation of the sealing ability of CC with glass ionomer (GI) using an electrochemical test showed a statistically significant difference between CC and GI regarding microleakage, suggesting CC as a superior sealant compared to GI.[22]

Modaresi et al. investigated the sealing ability of CC sealer and calcium hydroxide using methylene blue penetration. Their results revealed that CC displayed significantly less microleakage as an apical barrier than calcium hydroxide.[23] An in vitro study demonstrated that the sealing ability of CC, measured by the dye penetration test, was better than MTA in blood-contaminated conditions and similar to MTA in dry- and saliva-contaminated conditions.[25] In the present case series, canals were not completely dried out, indicating the plausible functioning of CC in the presence of some moisture and the fact that the remnants of normal saline in the canal could not interrupt treatment.

Dental filling materials must be non-toxic and biocompatible with host tissues; several in vitro and in vivo studies have evaluated the biocompatibility of CC [26-28] and shown that the pH value of CC after mixing (roughly 7.36) could rise to 10.1, 10.8, and 11.2 after 1 hour, 2 hours, and seven days, respectively, indicating that CC could slowly create an alkaline environment. [28]

In contact with tissues, CC can trigger cementum deposition, bone formation, and periodontal ligament regeneration.[21] Modaresi et al. showed periodontal ligament formation at the root end of the tooth after apexification with cold ceramic, suggesting the possibility of the formation of new cementum on the CC surface. Tissue regeneration around the root confirms the positive effects of cold ceramics on bone repair and periapical lesion healing.[29] In three out of six cases described here (i.e., cases 1,2, and 4), obturation of the root canal with CC was accompanied by the repair of periodontium and tooth-supporting tissues.

There is a possibility of overfilling of sealant materials to periapical spaces in open apexes, immature roots, and blunderbuss teeth, as well as apical resorption, iatrogenic apical destruction, and constriction. In these circumstances, biocompatible materials with gradual resorption and healing characteristics can be appropriate.[30] In a study by Chang et al., a considerable amount of MTA (Dentsply, Tulsa Dental, Johnson City, Tennessee, USA) was extruded into the apical lesion during placement, and the extruded MTA seemed to undergo slight compression and resorption, moving down from the apical position. Regardless of MTA overfilling and resorption, healing around MTA was favorable compared to overfilled gutta-percha.[31] In this study, as observed in case No. 3, overfilled CC material was resorbed; the bone was healed completely, and tissue healing responses to overfilled material were largely unaffected. Therefore, the accidental overfilling of the material into the periapical space should not raise serious concerns, but conservative approaches are recommended.

Obturation with bio-ceramics is an innovative method for reviving teeth that are endodontically challenging to manage, such as those with large lesions and unresponsive to traditional fillings and sealers.[32] Despite the potential advantages of CC, some drawbacks are worth mentioning, including challenges in determining newly formed tissues, calcification-mediated root canal obliteration, and limitations in retreatment.

Conclusion

Considering the results obtained and the importance of sealing during dental root canal treatment, especially in teeth with necrotic and infectious canals, it seems that CC can be a suitable option due to its absorbability when overfilling occurs in wide canals without needing apical stop for canal obturation. Evidence of periapical and furcation lesions may favor the use of this substance for treating such lesions. More studies are recommended to compare CC with other bio-ceramic materials and reach more robust conclusions.

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Data Availability Statement: The datasets generated during and/or analyzed during the current study are available

from the corresponding author upon Advancement of science.".

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